Antenna Noise Temperature

A $R_x$ will receive noise from both terrestrial and extra-terrestrial sources:

Q: What is the average spectral power density $N(f)$ of this received noise? ??

A: Generally speaking, it is white noise. !

⇒ i.e., the spectral power density of the noise is a constant wrt frequency (or, at least, within the antenna bandwidth).
Therefore, as far as noise is concerned, the receiver appears to have a resistor attached to it!!

\[ N(t) = N_0 = kT \text{ (white)} \]

If the antenna couples external noise into the receiver with average spectral power density \( N_0 \), the we define antenna temperature \( T_A \) as:

\[ T_A = \frac{N_0}{k} \]
Or, in other words, we describe the spectral power density of the input noise as:

\[ N_0 = k T_0 \]

So we could describe the noise with \( N_0 \), in Watts/Hz, or with \( T_0 \), in degrees Kelvin.

\[ \text{Note: The higher the antenna temperature } T_a, \text{ the larger the average spectral power density.} \]

Q: What typically is the value of \( T_a \)?

A: It depends on which direction the antenna is pointed!!
- If the antenna is pointed toward the sky (e.g., satellite communication), the antenna noise temperature could be $< 10^5$ K.

- If the antenna is not pointed at the sky, the antenna temp. is typically the physical temperature of the Earth! (There are physical reasons for this.).
So we often assume that $T_a \approx 290 \, ^\circ K$ for terrestrial applications.

\[
N_0 = k \frac{T_a}{(1.38 \times 10^{-23})} (290)
= 4 \times 10^{-21} \, \text{W/Hz}
= -174 \, \text{dBm/Hz}
\]